KINETICS OF WATER ADSORPTION ON ACTIVATED CARBONS

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Introduction

Water adsorption on activated carbons is a complex phenomenon involving several parameters related to the textural and functional characteristics of the material as well as the surrounding conditions. Under real operating conditions, water molecules from the surrounding atmosphere tend to infiltrate and preempt adsorption sites reserved for other target molecules (organic vapours for example) or to influence the kinetics of the adsorption, thereby compromising the role of the carbon[1-3]. In this context, the study of the kinetic of adsorption of water on activated carbons maybe useful since the material is often in contact with humidified air. In this study, two different commercial activated carbons are used for the evaluation of the kinetic of adsorption of water by varying several parameters that may influence the adsorption of water. These parameters are air flow, height of the carbon bed, relative humidity, temperature and the particle size of the absorbent.

Materials and Methods

Different commercial activated carbons, Norit CGranular (two different particle sizes) and Norit R1 are used in this study. The samples present different porosity and surface chemistry. Table 1 gives their characteristics. The water uptake is measured gravimetrically using the installation summarized by the scheme given in figure 1. The humidified air passes through the activated carbon filter, which retains an amount of water that is translated by a gain in weight until saturation (the weight of the filter becomes stable). Furthermore, Microtomography is carried out using Sky-scan-1074 X-ray Scanner (Skyscan, Belgium) to follow the adsorption of water in the carbon bed nearby in situ.

Table 1. Characteristics of the commercial samples used in this study

Sample	Sample designation	Shape	particle size (mm)	S_{BET} (m^2/g)	$V_{microporous}$ (cm^3/g)	V_{total} (cm^3/g)	[O][4] (%)
Norit CGranular1	CG1	Granular	1-2	1427	0.51	1.13	18.9
Norit CGranular2	CG2	Granular	0.5-0.8	1427	0.51	1.13	18.9
Norit R1	NR1	extruded	0.5-5 length 0.8 diameter	1358	0.47	0.64	13.0

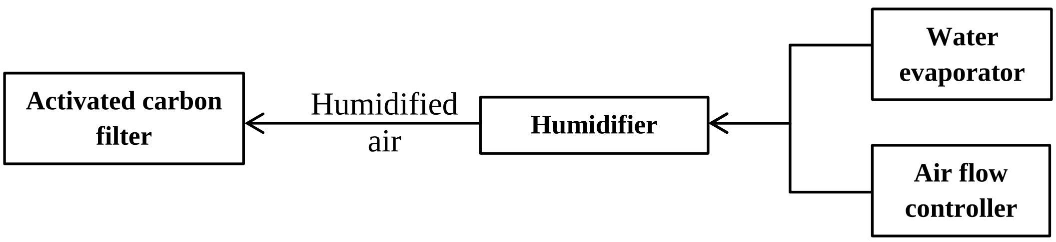

Figure 1. Scheme of the installation used for the tests

Results and Discussion

The samples are weighed at regular intervals to obtain a curve for weight loss/gain (W) versus time until the variation of weight (ΔW) is as close as possible to 0. The effect of several parameters (air flow, relative humidity, height of the carbon bed, particle size and particle size) on the kinetics of adsorption is evaluated. The experimental results will be correlated using a linear driving force equation: $\frac{\Delta W(t)}{\Delta W max} = (1 - e^{-a.t})$…*(eq 1)*

Where $\Delta W(t)$ is the mass gained as a function of time (g/g_{carbon}) and ΔW_{max} is the maximum weight gained at saturation (g/g_{carbon}) and a is a kinetic constant (min^{-1}). Figure 2 gives the W(t)=f(t) as a function of the variation of relative humidity and air flow. Results are given for tests that were carried out with CG1 and a height bed of 4 cm under an ambient temperature of 22 °C. Figure 3 represents a comparison between calculated values obtained with equation 1 and the experimental data for a test carried out with 85 % of relative humidity.

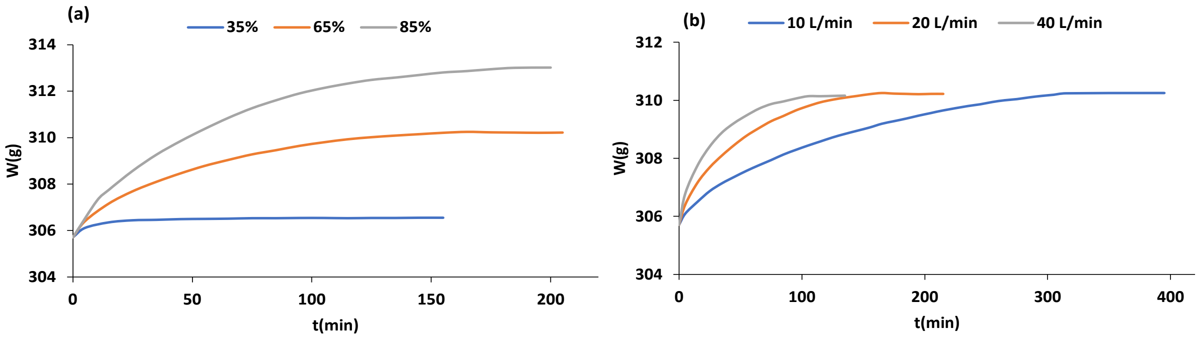

Figure 2. Kinetic of adsorption of water vapour as a function of different (a) relative humidity and (b) air flow.

From these primary results, we can notice that both the relative humidity and air flow have effect on the kinetics of adsorption of water. In fact, increasing the relative humidity decreases the rate of adsorption whereas the latter decreases when increasing the air flow. The other parameters need to be assessed. Furthermore, the comparison of the results obtained by the equation 1 and the experimental data shows that a linear driving force model is suitable for describing the adsorption kinetics of water vapour.

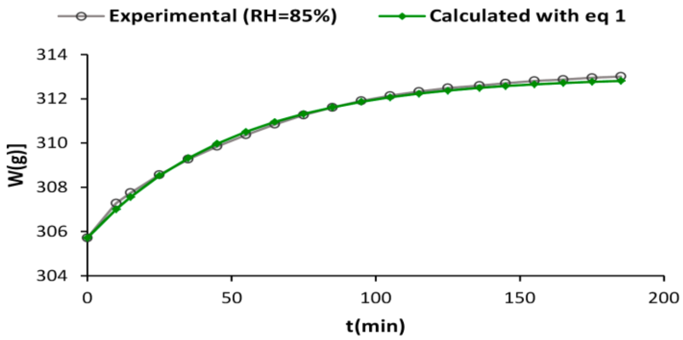

Figure 3. Comparison between experimental data and calculated values obtained by the equation 1.

Conclusions

Linear driving force model fits the experimental results, this makes it suitable for describing the adsorption kinetics of water vapour. Moreover, the experimental results show that different parameters such as relative humidity and air flow have an influence on the kinetics of adsorption.

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